Update on Ultra Low Latency Detection of Active Fires using VIIRS and MODIS

Liam Gumley, Bruce Flynn, Steve Dutcher
CIMSS / SSEC / University of Wisconsin-Madison

May 3, 2022

MODIS/VIIRS Ultra Low Latency Fire Detection

We have developed a system to receive, decode, and process MODIS and VIIRS data as quickly as possible.

The goal is to detect active fires (in CONUS) within *60 seconds* of observation on the spacecraft.

Direct broadcast data are the key to making this possible.

Multiple antenna sites provide the best coverage and reliability.

Antennas participating in this project

Madison, WI

Honolulu, HI

Monterey, CA

Hampton, VA

Mayaguez, PR

Madison, WI

Typical 24-hour reception schedule for Madison

Tracking Schedule for Pedestal_1 on 03-**May-2022** 20:23:55

92054	AQUA	N	10	DAY	03-**May-2022** 20:33:28	03-**May-2022** 20:36:21
92053	NPP	N	09	DAY	03-**May-2022** 20:36:21	03-**May-2022** 20:43:37
92055	FENGYUN 3D	N	10	DAY	03-**May-2022** 20:54:13	03-**May-2022** 21:02:09
92028	NOAA 19	S	05	DAY	03-**May-2022** 22:43:18	03-**May-2022** 22:47:15
92070	SARAL	S	29	DAY	03-**May-2022** 23:23:47	03-**May-2022** 23:35:41
92076	ANGELS	S	42	DAY	03-**May-2022** 23:40:21	03-**May-2022** 23:49:50
92094	NOAA 19	N	42	MIXED	04-**May-2022** 00:18:00	04-**May-2022** 00:31:04
92101	METOP-C	S	08	NIGHT	04-**May-2022** 00:48:39	04-**May-2022** 00:54:51
92085	SARAL	S	35	DAY	04-**May-2022** 01:03:05	04-**May-2022** 01:15:11
92086	ANGELS	S	13	DAY	04-**May-2022** 01:15:11	04-**May-2022** 01:22:22
92103	METOP-B	N	20	MIXED	04-**May-2022** 01:32:36	04-**May-2022** 01:43:37
92114	NOAA 19	N	27	MIXED	04-**May-2022** 01:59:09	04-**May-2022** 02:11:28
92115	NOAA 18	N	20	MIXED	04-**May-2022** 02:11:28	04-**May-2022** 02:18:26
92128	METOP-C	N	54	MIXED	04-**May-2022** 02:24:08	04-**May-2022** 02:37:14
92129	TERRA	N	22	NIGHT	04-**May-2022** 02:37:14	04-**May-2022** 02:47:14
92089	METOP-B	N	57	MIXED	04-**May-2022** 03:11:10	04-**May-2022** 03:24:22
92109	NOAA 18	N	62	NIGHT	04-**May-2022** 03:46:21	04-**May-2022** 03:59:52
92125	METOP-C	N	20	NIGHT	04-**May-2022** 04:05:32	04-**May-2022** 04:16:39
92126	TERRA	N	42	NIGHT	04-**May-2022** 04:16:39	04-**May-2022** 04:25:25
92096	METOP-B	N	05	NIGHT	04-**May-2022** 04:57:11	04-**May-2022** 05:00:36
92092	NOAA 18	N	06	NIGHT	04-**May-2022** 05:32:06	04-**May-2022** 05:37:27
92116	NOAA 20	S	14	NIGHT	04-**May-2022** 06:21:10	04-**May-2022** 06:31:07
92107	AQUA	S	19	NIGHT	04-**May-2022** 06:52:03	04-**May-2022** 07:02:02
92108	GCOM-W1	S	22	NIGHT	04-**May-2022** 07:02:02	04-**May-2022** 07:05:15
92093	NPP	S	40	NIGHT	04-**May-2022** 07:09:34	04-**May-2022** 07:22:28
92105	FENGYUN 3D	S	37	NIGHT	04-**May-2022** 07:28:03	04-**May-2022** 07:40:50
92098	NOAA 20	S	73	NIGHT	04-**May-2022** 08:00:13	04-**May-2022** 08:13:35
92117	AQUA	S	47	NIGHT	04-**May-2022** 08:29:10	04-**May-2022** 08:40:51
92118	GCOM-W1	S	39	NIGHT	04-**May-2022** 08:40:51	04-**May-2022** 08:43:37
92110	NPP	S	28	NIGHT	04-**May-2022** 08:50:04	04-**May-2022** 09:02:02
92090	FENGYUN 3D	S	30	MIXED	04-**May-2022** 09:08:27	04-**May-2022** 09:20:39
92127	NOAA 20	S	11	NIGHT	04-**May-2022** 09:42:05	04-**May-2022** 09:50:17
92088	ANGELS	N	23	DAY	04-**May-2022** 10:21:17	04-**May-2022** 10:30:00
92087	SARAL	N	47	DAY	04-**May-2022** 10:41:51	04-**May-2022** 10:54:24
92124	ANGELS	N	24	DAY	04-**May-2022** 11:55:07	04-**May-2022** 12:04:00
92104	SARAL	N	21	DAY	04-**May-2022** 12:22:12	04-**May-2022** 12:33:16
92091	NOAA 19	S	16	DAY	04-**May-2022** 12:39:29	04-**May-2022** 12:50:00
92097	NOAA 19	S	71	DAY	04-**May-2022** 14:19:03	04-**May-2022** 14:32:46
92095	METOP-C	S	20	DAY	04-**May-2022** 14:40:55	04-**May-2022** 14:52:00
92106	METOP-B	S	53	DAY	04-**May-2022** 15:27:20	04-**May-2022** 15:40:28
92133	NOAA 19	S	11	DAY	04-**May-2022** 16:01:18	04-**May-2022** 16:07:03
92132	NOAA 18	S	52	DAY	04-**May-2022** 16:07:03	04-**May-2022** 16:11:59
92131	TERRA	S	44	DAY	04-**May-2022** 16:11:59	04-**May-2022** 16:20:20
92130	METOP-C	S	54	DAY	04-**May-2022** 16:20:20	04-**May-2022** 16:33:24
92099	NPP	N	11	DAY	04-**May-2022** 16:56:38	04-**May-2022** 17:05:01
92119	METOP-B	S	22	DAY	04-**May-2022** 17:08:00	04-**May-2022** 17:19:13
92120	FENGYUN 3D	N	10	DAY	04-**May-2022** 17:19:13	04-**May-2022** 17:23:28
92080	NOAA 20	N	28	DAY	04-**May-2022** 17:44:57	04-**May-2022** 17:57:00
92083	TERRA	S	21	DAY	04-**May-2022** 17:57:00	04-**May-2022** 17:58:56
92082	AQUA	N	24	DAY	04-**May-2022** 17:58:56	04-**May-2022** 18:02:44
92081	METOP-C	S	07	DAY	04-**May-2022** 18:02:44	04-**May-2022** 18:08:51
92084	GCOM-W1	N	28	DAY	04-**May-2022** 18:08:51	04-**May-2022** 18:12:31
92112	NPP	N	75	DAY	04-**May-2022** 18:33:26	04-**May-2022** 18:46:49
92102	FENGYUN 3D	N	70	DAY	04-**May-2022** 18:52:05	04-**May-2022** 19:05:25
92121	NOAA 20	N	39	DAY	04-**May-2022** 19:24:35	04-**May-2022** 19:37:27
92122	AQUA	N	38	DAY	04-**May-2022** 19:37:27	04-**May-2022** 19:47:29
92123	GCOM-W1	N	32	DAY	04-**May-2022** 19:47:29	04-**May-2022** 19:50:22
92111	NPP	N	14	DAY	04-**May-2022** 20:16:00	04-**May-2022** 20:25:48

Reception Priorities (1=highest)

1. Suomi NPP, NOAA-20
2. Metop-B, Metop-C
3. Terra, Aqua
4. NOAA-18, NOAA-19
5. GCOM-W1
6. FY-3D
7. SARAL, ANGELS

11 SNPP/NOAA-20 passes
8 Terra/Aqua passes
11 Metop-B/C passes
10 NOAA-18/19 passes

58 total passes

MODIS/VIIRS Direct Broadcast

NOAA-20, Suomi NPP, Terra, and Aqua provide real-time direct broadcast (DB) of sensor observations on X-band.

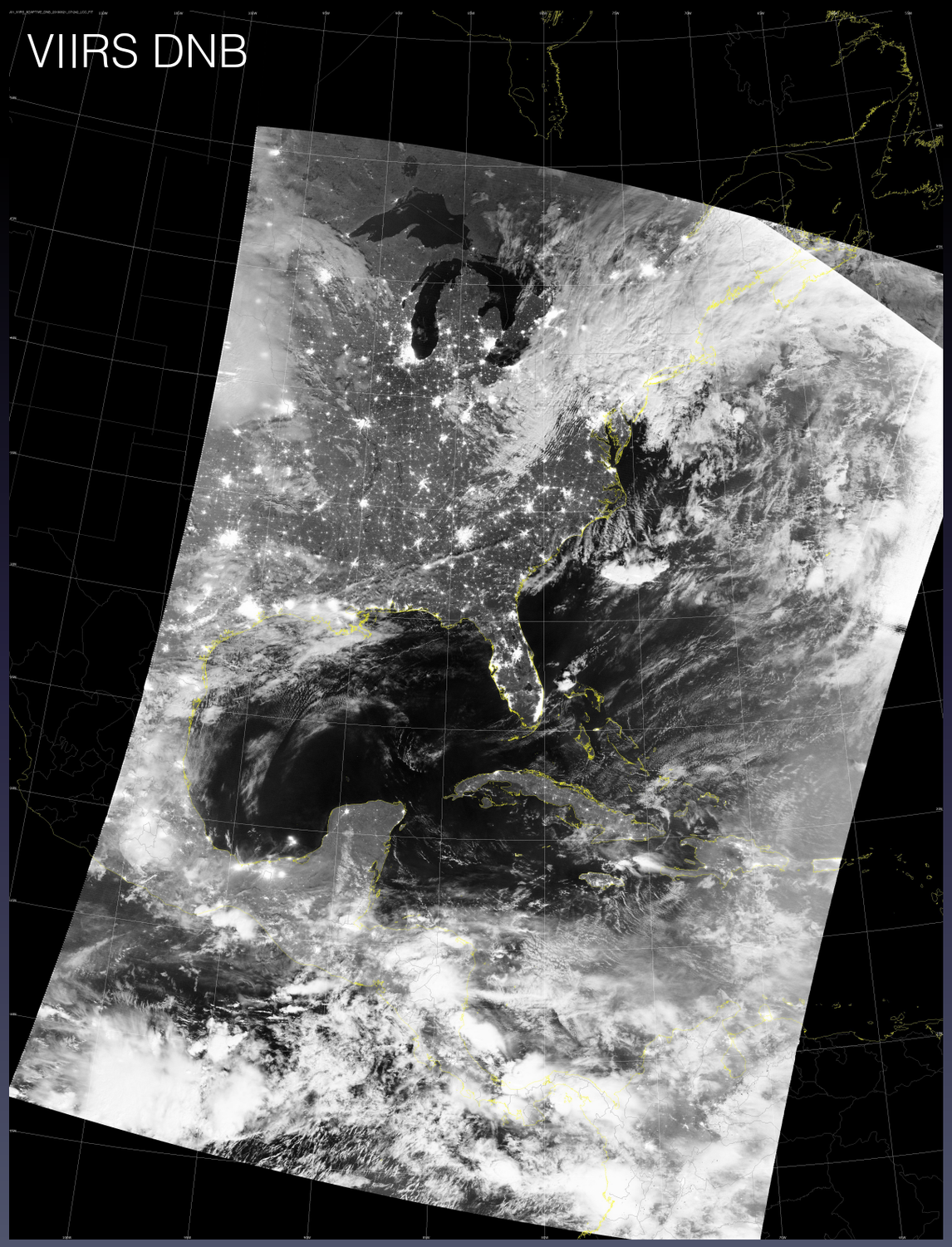
Affordable X-band antennas for receiving and decoding these DB transmissions have been available for > 20 years (starting with Terra in 2000).

Freely available software for decoding and processing the data makes it possible to create Level 1B and Level 2 products from the DB data.

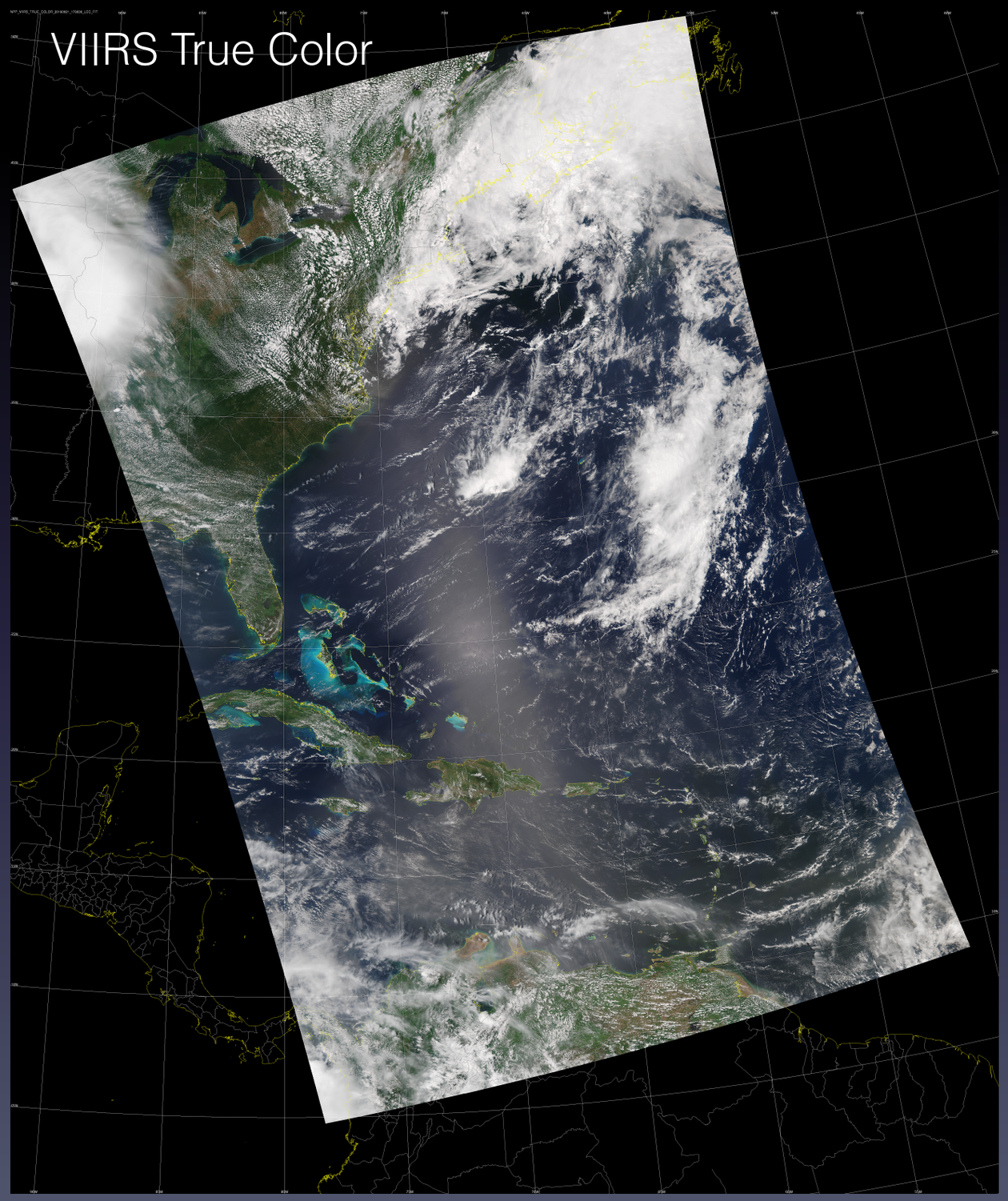
VIIRS Direct Broadcast Data Coverage

NOAA-20 Direct Broadcast data from Miami antenna 2019/06/21

VIIRS DNB



VIIRS True Color



Enabling factors for ultra low latency

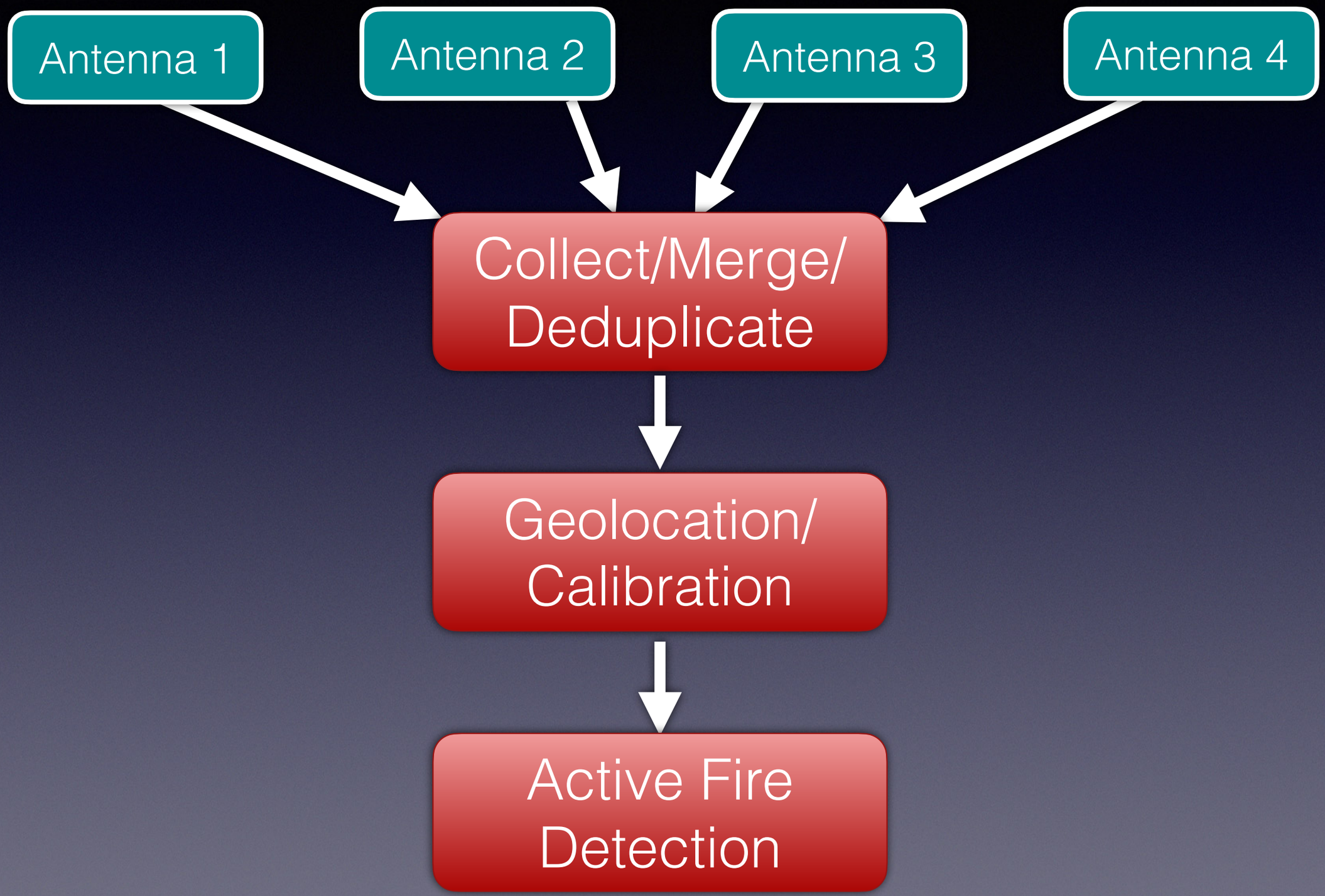
1. Direct access to multiple DB antennas in CONUS (Madison WI x 2, Hampton VA, Mayaguez PR).

2. Software systems to stream the DB data (as CCSDS packets) in real-time from each antenna to a central collection point.

3. Software systems to ingest, merge, and de-duplicate the CCSDS packets in real-time.

4. Software systems to process “micro-granules” through Level 1 (geolocation, calibration) and Level 2 (active fire detection).

Ultra Low Latency Data Flow



Data Ingest & Processing Workflow

1. CCSDS Level 0 packets are streamed in real time from multiple remote antenna sites to a merging/de-duplication application at SSEC.

2. De-duplicated packets are streamed to a collector application that assembles 5-second buckets. A message is sent when a new 5-second bucket has been populated.

3. A processor application listens for messages from the collector, and when it has sufficient data to process (e.g., 7 complete scans of MODIS Level 0 data ~10.34 sec) it starts the processing for that “micro granule”.

4. The processor immediately runs the Level 1A/GEO/CAL software followed by the active fire detection.

MODIS Latency Summary

Earth observation window	10.3 sec
Ground system	3.5 sec
Level 1 processing	10.0 sec
Active Fire Detection	0.5 sec
Total latency (relative to start of observation window)	**24.3 sec**

Current Status

- Ultra low latency data are received from Madison (x 2 antennas), Hampton, and Mayaguez.
- Standard low latency data are received from Honolulu and Monterey (after the pass is complete).
- MODIS data are processed via OCSSW and MOD14; VIIRS data are processed via VIIRS L1 and VFIRE375.
- Fire locations are converted to CSV and are provided to LANCE/FIRMS via Web API.
- MODIS latency is ~ 25 seconds; VIIRS is ~ 50 seconds for data ingested and processed in real time.
- Have tested VIIRS data ingest from two antennas in Brazil; have requested VIIRS data from Univ. of Alaska Fairbanks.

Current and Planned Coverage